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STRUCTURAL MODELING

LITERATURE SEARCH NO. 523

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MARCH 1963

JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIFORNIA

ASTRONAUTICS INFORMATION

STRUCTURAL MODELING

LITERATURE SEARCH NO. 523

COMPILED BY
JUDITH HAYES

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

MARCH 1963

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FOREWORD

This literature-reference compilation has been prepared at the request of personnel at the Jet Propulsion Laboratory (JPL) and is published for distribution to interested organizations working in the field of astronautics.

As the size of spacecraft has enlarged, making full-scale tests economically unfeasible, the use of models in aeroelasticity tests has become increasingly important. The references in this search pertain to the construction of models to be used in such tests. The construction of rigid models was not, in general, considered.

References are arranged in chronological order by year. Author and source indexes are included.

The following abstract sources were covered:

Armed Services Technical Information Agency, 1955–1959

JPL Library Additions Card File (1954–1961 approximately)

Aeronautical Engineering Review, 1955–1957

Aero-Space Engineering, 1958, 1959, and July–December 1960

Applied Mechanics Review (AMR), 1952–1953, 1955–1961

Applied Science and Technology Index (AS&T), 1958–1960

Engineering Index (EI), 1959–1960

International Aerospace Abstracts (IAA), 1961

Additional sources were also consulted.

The compiler wishes to thank Theodore Lang for his assistance in the selection of material.

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STRUCTURAL MODELING

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   Beggs, G. E.
   Journal of the Franklin Institute, v. 203, pp. 375–386, 1927

2. DIMENSIONAL ANALYSIS
   Bridgman, P. W.
   Yale University Press, New Haven, Conn., Revised Edition, 1931

3. THE DETERMINATION OF EARTHQUAKE STRESSES IN ELASTIC STRUCTURES BY MEANS OF MODELS
   Ruge, A. C.
   Seismological Society of America, Bulletin of the, v. 24, no. 3, pp. 169–230, July 1934

An analytical study of the theory and application of mechanical models to framed structures is presented. The general method of analysis illustrates a style of reasoning which could be used in developing models for various special purposes.

4. MODEL MEASUREMENTS AND AIRSHIP STRESS ANALYSIS
   Donnell, L. H.
   July 1935
   Daniel Guggenheim Airship Institute, Akron, Ohio
   Publication 3

5. STRESS MODEL OF COMPLETE AIRSHIP STRUCTURE
   Donnell, L. H., Shaw, E. L., Potthoff, W. C.
   ASME Transactions, v. 60, pp. A-67–A-77, June 1938

Considerations in designing stress models are discussed in general, and the construction, rigging, and testing of an airship model in particular. A new type of girder representation is described which has the unusual advantages of varying the axial, bending, and torsional characteristics independently, and of incorporating convenient and sensitive means for measuring the corresponding stresses. Tests on a separate braced-ring model are compared with theory, and appear to be in good agreement. Similar tests on a duplicate ring in the complete model show the influence of the surrounding structure.

6. NOTES ON RECENT STRUCTURAL RESEARCH AT GOODYEAR-ZEPPELIN CORPORATION
   Arnstein, K., Shaw, E. L.
   Journal of the Aeronautical Sciences, v. 6, no. 10, pp. 499–501, October 1939

The use of models to predict the full-scale behavior of a structure, specifically of a complete airship model, is reviewed. Stability models and the use of a stress change recorder are described.

7. DYNAMIC TESTS ON BRIDGE MODELS
   Farquharson, F. B.
   Engineering News-Record, v. 127, no. 1, pp. 37–39, July 3, 1941

Theories of stress and deflection relationships between model and prototype in tests on models of suspension bridges are discussed. Force scales and velocities for various space scales are given. Plans for a new laboratory are presented. (*EI*, 1941)

8. REPORT ON CONSTRUCTION AND TESTING OF A LOW SPEED FLUTTER MODEL OF THE GRUMMAN F6F
   Beckley, L. E., Kennedy, C. C., Rauscher, M.
   March 19, 1943
   Massachusetts Institute of Technology, Flutter Research Laboratory, Cambridge
   Report, Contract A-9730

9. FAILURE OF TACOMA NARROWS BRIDGE
   1944
   Texas, Agricultural and Mechanical College of, Engineering Experiment Station, College Station
   Bulletin 78

A contribution to work of Advisory Board on Investigation of Suspension Bridges by United States Public Roads Administration and Agricultural and Mechanical College of Texas is presented. (*EI*, 1944)

10. APPLICABILITY OF SIMILARITY PRINCIPLES TO STRUCTURAL MODELS
    Goodier, J. N., Thomson, W. T. (Cornell University, Ithaca, N.Y.)
    1944
    National Advisory Committee for Aeronautics, Washington, D.C.
    TN-933

A systematic account is given of the use of dimensional analysis in constructing similarity conditions for models and structures. The analysis covers large deflections, buckling, plastic behavior, and materials with nonlinear stress-strain characteristics, as well as the simpler structural problems. Tests of the validity of these similarity principles were made on buckled thin square plates in shear, with and without holes.

11. STRUCTURAL MODEL TESTING
Loudenslager, O. W.
SAE Journal, Transactions Section,
v. 54, no. 1, pp. 18–25, January 1946

Unusually precise structural model design, construction, and test procedure are discussed in detail. A statement is given of the laws of similarity to which all structural models must conform if precise results are to be obtained in the simplest manner. Scale selection, choice of materials, and construction methods are all considered. Three model members of designs, which can represent a number of prototype properties, are described in detail. The use of each of these members, and the determination of bending, torsional, tensile, and comprehensive stresses by means of simple equipment is discussed. In addition, design formulas are proposed for a member which represents the axial, torsional, and bending (in two planes) properties.

Finally, three test procedures, all applicable to a variety of simple or complicated indeterminate structures, and the methods used in evaluating the test results are presented. Briefly, these are: tests in which influence lines are photographed so that axial and bending stresses in redundant structures can be determined; stability tests for determining buckling strength; and tests to give bending and other stresses.

12. HYDROSTATIC INVESTIGATION OF NON-RIGID AIRSHIP
Loudenslager, O. W., Gardner, R. C.
1946(?)
Goodyear Aircraft Corporation, Akron, Ohio
R-55-41, Part II (unpublished)
(Reference from journal article, see Entry #11)

13. THEORY FOR DESIGN OF STRUCTURAL MODELS
Loudenslager, O. W.
1946(?)
Goodyear Aircraft Corporation, Akron, Ohio
R-55-44, Part I (unpublished)
(Reference from journal article, see Entry #11)

14. ELASTIC STABILITY MODEL TEST OF AIRSHIP HULL STRUCTURES BETWEEN MAIN FRAMES
Shaw, E. L., Loudenslager, O. W.
1946(?)
Goodyear Aircraft Corporation, Akron, Ohio
R-55-34, Parts I, II, III (unpublished)
U.S. Navy Contract 47423
(Reference from journal article, see Entry #11)

15. AERODYNAMIC STABILITY OF SUSPENSION BRIDGES
Farquharson, F. B.
***Western Society of Engineers—Journal,* v. 52, no. 3, pt. 1, pp. 141–150, September 1947**

Notes are given on a wind-tunnel investigation of a model on which the design of the New Tacoma Narrows Bridge is based. The theory of J. P. Den Hartog which seemed to shed light on the phenomenon proved inadequate, and was replaced by one involving interpretation of "vortex shedding" from stiffening girders. An illustrated description of tests is presented with a discussion of findings. (*EI*, 1948)

16. WING FLUTTER EXPERIMENTS WITH VARIATIONS IN STIFFNESS AND DISTORTION FORM
Hall, A. H.
March 17, 1948
National Research Council of Canada, Montreal Laboratory
AR-6, MM-203

17. NOTE ON FLEXURAL SIMILARITY OF STRUCTURES
Charlton, T. M.
***Civil Engineering,* London, v. 43, no. 507, pp. 456–459, September 1948**

The principle of stress analysis and the determination of natural frequencies of forced vibration amplitudes of structures are studied by means of a scale model. Flexural similarity of structures and computation of conversion factors from model to actual system are presented. (*EI*, 1948)

18. AERODYNAMIC STABILITY OF SUSPENSION BRIDGES WITH SPECIAL REFERENCE TO THE TACOMA NARROWS BRIDGE. PART I: INVESTIGATIONS PRIOR TO OCTOBER, 1941
Farquharson, F. B.
June 1949
University of Washington Engineering Experimental Station, Seattle
Bulletin 116, Part I

This part deals with all laboratory studies conducted prior to the design of the new laboratory in which wind-actuated dynamic models were investigated. Of particular interest are the chapters entitled "The Problem of Similitude as it Affects the Design of Models" and "The Mechanically Operated Dynamic Model."

19. A STUDY OF MODELING FOR DYNAMIC STRESS SIMILITUDE
Hermes, R. M.
1950
California Institute of Technology, Pasadena
Thesis

The prediction of stresses developed in structures subjected to dynamic loading constitutes a problem which is receiving increased attention. The use of models for this prediction offers an economical and practical solution to this problem. The modeling parameters for vibrating beams are developed through an analysis in which the equations of motion are reduced to dimensionless form. The validity of these modeling parameters has been tested experimentally. These experiments are reported, and it is shown that this method of analysis can be extended to problems involving plates and frames.

and construction of a full aerodynamic model of the original Tacoma Narrows Bridge to a linear scale factor of 50. Erection of the model is described, illustrating how it was finally positioned by the use of hydraulic jacks.

Behavior of the above model in the wind tunnel is considered under varying wind velocities and construction modifications, such as the addition of circular fairing and closed and open decks. Symmetric and asymmetric modes are plotted for various conditions along with other pertinent data. Side-span modifications are described utilizing unloaded back-stay condition as well as side spans replaced by springs. Effectiveness of diagonal tower stays and the effect of altering model tower torsional stiffness is investigated. In addition to tests on the above model, tests are described on "section" dynamic models under three different mounting conditions. It is shown that a dynamic section model represents a short section of suspended structure, and should be built to scale with respect to weight and shape if it is to represent the characteristics of the section. Numerous double amplitude "plots" are given for varying conditions.

The preceding studies are summarized and compared with tests made at the California Institute of Technology by von Karman and Dunn. Complete tabulation of $(V/Nb)_c$ for all configurations and models for vertical and torsional oscillations are given.

It is believed that this work will serve as a classic in wind-tunnel and model construction, instrumentation, and future operation for those who will be concerned with the effect of aerodynamic forces on suspension bridges. It is also demonstrated that careful experimentation with scale models can predict, with reasonable accuracy, the performance of the prototype under action of a perfect wind. However, the impact of a natural wind on a given (or proposed) bridge is still beyond definite prediction, and, for this reason, critical judgment should be exercised in interpreting model tests. (*AMR*, 1952, #3382)

27. STRUCTURAL ANALYSIS BY MODELS
Pell, P. S., Thompson, N. E., Coates, R. C.
***Civil Engineering*, London, v. 47, no. 553, pp. 559–561 July 1952; no. 554, pp. 666–667, August 1952**

A brief description is presented of the analysis of indeterminate structures by the use of models. Examples in which experimentally determined quantities are compared with calculated values are included. The techniques followed and the models and instruments used, including the Ruge-Schmidt moment indicator, are described and references to more extended discussions are given. (*AMR*, 1953, #1216)

28. FLUTTER ANALYSIS OF COMPLEX AIRPLANES BY EXPERIMENTAL METHODS
Kinnaman, E. B.
***Journal of the Aeronautical Sciences*, v. 19, no. 9, pp. 577–584, September 1952**

Analysis of the flutter potentialities of a highly elastic airplane having a wing of high aspect ratio with large flexibly mounted concentrated masses distributed along the span has proved to be amenable to solution by the use of elastically and dynamically scaled wind-tunnel models. Experimental flutter testing at Boeing has progressed from a simple half-wing cantilever model of 1946 to almost completely scaled flutter models tested in reasonable simulation of free flight.

Continued development of experimental flutter analysis techniques and correlation with full-scale flight testing and theory are needed to permit more accurate predictions of the flutter characteristics of an airplane prior to the final design and flight stages.

29. MATHEMATICAL PREDICTION OF SUSPENSION BRIDGE BEHAVIOR IN WIND FROM DYNAMIC SECTION MODEL TESTS
Vincent, G. S.
***Publications of the International Association for Bridge Structural Engineering*, v. 12, pp. 303–321, 1952**

Wind-tunnel tests on three-dimensional models of suspension bridges show sufficient correlation with the behavior of the actual bridges to indicate that the scale effect is small. Static wind-tunnel tests on models show that the effect of Reynolds number on drag, lift, and moment is negligible. When the logarithmic decrement for atmospheric damping in still-air model tests is plotted against amplitude of oscillation, the resulting curves reveal the action of forces whose strength varies as the square of the velocity with only a small component of viscous damping, indicating that the phenomenon follows Froude's law. These facts make it possible to use aerodynamic section-model tests to predict the behavior of the bridge in the wind.

When a section model (properly scaled to form, mass, and mass distribution) is supported on springs designed to reproduce to scale the vertical, torsional, and coupled movements of the prototype, and is exposed in a wind stream, the flow will be similar and the wind forces will be proportional to those associated with the prototype under corresponding conditions. The continuous record of the motion of the model will reveal the integrated work performed on it by the wind forces, and will indicate the rate per cycle at which the wind transfers energy to the oscillating system. This rate, which varies with the amplitude, will be the same on the prototype as on the model, the latter representing the conditions over a unit length of the prototype oscillating at a discrete amplitude. The energy transfer per cycle on the prototype can be calculated by integration over the length of the structure using the previously computed frequency and wave form of the mode under investigation. The steady-state amplitude in the given wind stream will be that at which the total energy input per cycle just equals that absorbed by the structural damping. The latter, for the prototype, must be known or assumed.

The structural damping of the model mechanism is obtained from tests with equivalent streamlined weights substituted for the section model. When this is subtracted from the damping of the model assembly in still air or a wind stream, the atmospheric damping for that condition is obtained. The tests are extended to sufficient amplitude to include the ranges of positive and negative atmospheric damping. The integration for the prototype is facilitated by expressing the logarithmic decrement as a power series in the amplitude. The curves vary much in form for different velocities. (*AMR*, 1953, #1221)

30. SIMILARITY LAWS FOR STRESSING HEATED WINGS
Tsien, H. S.
***Journal of the Aeronautical Sciences*, v. 20, no. 1, pp. 1–11, January 1953**

Differential equations for a heated plate with large temperature gradient and for a similar plate at constant temperature can be made the same by proper modification of thickness and loading for an isothermal plate. Thus, stress in the heated plate can be calculated from measured strains on the unheated plate by a series of relations called "similarity laws." This theory is applied to solid wings under aerodynamic heating. (*EI*, 1953)

31. PRELIMINARY RESULTS OF SUPERSONIC-JET TESTS OF SIMPLIFIED WING STRUCTURES
Heldenfels, R. R., Rosencrans, R.
July 8, 1953
National Advisory Committee for Aeronautics, Langley Aeronautical Laboratory, Langley Field, Va.
RM L53E26a

Seven small multiweb structures were tested under simulated supersonic flight conditions to investigate the structural effects of aerodynamic heating. Three models experienced chordwise flutter and failure; the other four incorporated structural modifications that prevented flutter. The tests are discussed, and it is concluded that the models failed as a result of the combined action of aerodynamic heating and loading.

32. ON THE DESIGN OF MODELS FOR HELICOPTER RESEARCH AND DEVELOPMENT
Goland, L.
October 1953
Princeton University, Aeronautical Engineering Laboratory, Princeton, N.J.
Report 240, N6-onr-27015
AD-20,523

Information concerning the stability and control problem was obtained from flight tests of a small-scale helicopter model. The problems, usefulness, and limitations of dynamic model testing of helicopters are discussed. Reduction factors for the design of dynamically similar models are presented. These models are expected to exhibit stability and control characteristics similar to the prototype as well as similar rotor blade vibrations, deflections, and flutter characteristics.

33. MODEL SIMULATION OF TWIN-ROTOR HELICOPTER DYNAMIC STABILITY AND CONTROL. PHASE I. THEORETICAL ANALYSIS AND MODEL DESIGN
Gebhard, D. F.
November 1953
Princeton University, Aeronautical Engineering Laboratory, Princeton, N.J.
Report 242, N6-onr-27015
AD-25,266

A 6-ft-D twin-rotor model of the tandem configuration was designed to simulate a full-scale helicopter of the Piasecki HUP type. The model is powered by an induction-type 400-c 200-v motor located at approximately the center of the fuselage and installed in the horizontal shaft connecting the fore and aft rotor transmissions. A power output of up to 1.5 hp appears possible with this installation. A wooden blade, with a running blade weight (lacquered) of 0.0067 lb/in., was built and shaped by hand to a contour tolerance of ± 0.005 in. A theoretical dynamic analysis indicated that excellent longitudinal hovering characteristics can be obtained by introducing differential collective pitch which is proportional to pitching rate, and cyclic pitch which is proportional to pitch angle. In addition, differential induced torque effects will produce considerable coupling between the longitudinal and directional modes of motion.

34. DIMENSIONAL METHODS AND THEIR APPLICATIONS
Focken, C. M.
Edward Arnold and Company, London, England, 1953
(Available from St. Martin's Press, Inc., New York, N.Y.)

A critical survey, written for the engineer and physicist, of dimensions and related study of units is presented. It is intended to show the practical advantages of using dimensional methods. Various physical magnitudes—spatial, thermal, and electrical—are discussed. Physical and engineering applications are covered. (*EI*, 1954)

35. DIMENSIONAL ANALYSIS AND THEORY OF MODELS
Langhaar, H. S.
John Wiley and Sons, Inc., New York, N.Y., 1953

36. SOME CONSIDERATIONS ON THE AIR FORCES ON A WING OSCILLATING BETWEEN TWO WALLS FOR SUBSONIC COMPRESSIBLE FLOW
(Presented at the IAS 22nd Annual Meeting, New York, N.Y., January 25–29, 1954)
Woolston, D. S., Runyan, H. L.
January 1954
Institute of the Aeronautical Sciences, New York, N.Y.
Preprint 446
(See also *Journal of the Aeronautical Sciences*, v. 22, no. 1, pp. 41–50, January 1955)

The problem of the determination of the air forces on an oscillating airfoil between plane walls has, until recently, been treated only for incompressible flow. This paper is concerned with the important effects of compressibility, which may be of significance in such problems as the measurement of oscillating air forces or of wing flutter characteristics in wind tunnels, and in the flutter of airfoils in cascade. The possibility of an acoustic resonance phenomenon existing under certain critical conditions is discussed. The integral equation for the compressible case, as obtained by Runyan and Watkins in NACA TN-2552, is reviewed briefly and a method of solving the equation is given. The procedure is applied to a number of selected cases at various Mach numbers and tunnel heights. The effect of the presence of the walls is shown to be very significant near the resonant frequency, and, for certain conditions, to be large even at frequencies well removed from resonance.

37. PRELIMINARY DESIGN AND DEVELOPMENT OF A SANDWICH TYPE WING
Zimmerman, A. H.
April 26, 1954
Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y. Report AE-817-W-2, AF 33(616)91, AD-53, 498

Progress is reported on the development of suitable sandwich-type wing and tail surfaces for the F-80A 1/10-scale model. Efforts were directed toward developing a beam with less bending deflection per unit load than a balsa core beam and utilizing a core lighter than balsa. The core materials investigated were cast cellular Al, foamed plastic of various types, woods, and honeycombed Al foil. The Al honeycomb core had the best properties for the dynamic stability model. A frequency comparison was made for the beams containing balsa or Al honeycomb cores. Stiffness-to-weight ratios were determined, and a comparison was made to solid Al. The design and evaluation of the sandwich-type structure are discussed. Bonding of the metal skin to the core was made more effective with the use of phenolic and epoxy resins. Methods of contouring the honeycomb core are described.

38. A SURVEY OF SCALE EFFECTS ON THE HYDRODYNAMIC TESTING OF SEAPLANE MODELS
Parker, R.
1954
Aeronautical Research Council, London, Great Britain Current Papers 179

A general survey is made of all the factors where true dynamic similarity cannot be achieved in model tests of seaplane hulls. The likely effects on test results are then discussed with reference to towing tank models and medium-size research aircraft.

In resistance tests, the correction for Reynolds number effects requires more investigation; the artificial production of a turbulent boundary layer is the most likely means of achieving the required improvement in accuracy.

Pressure effects are likely to affect the break away of flow at small discontinuities such as extreme fairings with resultant errors in both stability and resistance test results. More accurate and systematic full-scale data than available at present are needed before methods of allowing for this can be satisfactorily developed. (*AMR*, 1956, #2652)

39. PLASTIC MODELS FOR VIBRATION ANALYSIS
Sankey, G. O.
***Society for Experimental Stress Analysis, Proceedings of the,* v. 11, no. 2, pp. 81–90, 1954**
(*AMR*, 1955, #2638)

40. MODEL INVESTIGATIONS CONCERNED WITH DRIVING PILES BY VIBRATION
Eastwood, W.
***Civil Engineering,* London, v. 50, no. 584, pp. 189–191, February 1955**

Experiments were conducted on a model scale to find the factors which affect the natural frequency of vertical vibration of piles. These experiments may offer some guidance to the range of frequencies which will be most likely to give resonance in full-scale attempts at driving piles by vibration.

Principal findings are summarized as follows:

(1) The natural frequency of vibration appears to be approximately constant for a given pile, whatever the depth of penetration.

(2) Increasing the total mass of a given pile reduced its natural frequency. However, the reduction was not quite as great as would be expected if the frequency were inversely proportional to the square root of the weight of the pile.

(3) Increasing the cross-sectional area of the pile decreases its natural frequency.

(4) The effect of inundating the sand was to slightly decrease the natural frequency compared with that for damp sand. (*AMR*, 1956, #338)

41. CONSIDERATIONS IN THE DESIGN OF STRUCTURAL MODELS
Raphael, C.
***Aeronautical Engineering Review,* v. 14, no. 2, pp. 52–55, February 1955**

Considerations that must be taken into account in structural model design are discussed. They include the following: geometric similarity, scale factor, boundary conditions, design equations, dimensional relationships, joint rigidities, and test setup.

42. SYNTHESIS OF BEAM-NETWORK STRUCTURES FOR LOW-ASPECT-RATIO FLUTTER MODELS APPENDIX A—DERIVATION OF STIFFNESS SUBMATRICES FOR A TWO-BAY LATTICE NETWORK

APPENDIX B—DERIVATION OF FLEXIBILITY SUBMATRICES FOR A THREE-BAY LATTICE NETWORK
APPENDIX C—EXPRESSIONS OF SUBMATRICES FOR MODEL WITH SIX CONTROL POINTS
Chen, M. M., Gravitz, S. I.
March 1955
Massachusetts Institute of Technology, Aero-Elastic and Structures Research Laboratory, Cambridge
TR 54-1

Methods for designing one-dimensional and lattice network structures to reproduce given sets of flexibility influence coefficients at pre-assigned control points over the structure are described. An iterative procedure is developed to solve the nonlinear relations in the unknown stiffnesses of the numbers of a lattice network used as elastic frameworks of the flutter models in the design and construction of static models related to the wing of the XF-92A. (*IAA*, March 1956)

43. DEFLECTION MEASUREMENTS ON A 45° SWEPT AND TAPERED RECTANGULAR TUBE
Belcher, G. L.
June 1955
Aeronautical Research Laboratories, Victoria, Australia
SM-228

Results are presented of tests on a DTD 390 aluminum model (representing the structural portion of a swept and tapered wing with ribs parallel to the line of flight) with the measured deflections compared to the predictions obtained by the Hall method, and with a determination of the influence coefficients for eight points of the tube subjected to a concentrated load at each of these points in turn (under the conditions allowing freedom of roll about the axis of symmetry by fitting the external ribs with axles running in self-aligning ball races mounted on a supporting framework rested on the floor). Provisions are made for corrections of deflection regions from dial gages. (*IAA*, March 1956)

44. STRUCTURAL MODEL STUDIES OF CONCRETE SLAB FOUNDATIONS
Pengelley, C. D., Dower, E. J., Lemcoe, M. M.
***Journal of the American Concrete Institute*, v. 26, no. 10, pp. 961–976, June 1955**

The theory of dimensional analysis is applied to the design of reinforced-concrete structural models of small home foundation slabs. Methods of fabricating satisfactory models are developed. Static stiffness measurements are reported on six different designs of the same cost and size. Two full-scale foundations were tested corresponding to a pair of the model designs, and model and full-scale results are compared. (*AMR*, 1957, #3224)

45. GUST-TUNNEL INVESTIGATION OF THE EFFECT OF A SHARP-EDGE GUST ON THE FLAPWISE BLADE BENDING MOMENTS OF A MODEL HELICOPTER ROTOR
Maglieri, D. J., Reisert, T. D.
August 1955
National Advisory Committee for Aeronautics, Washington, D.C.
TN-3470

By mounting a model helicopter rotor on the end of a whirling arm which passed through a vertical gust-simulating low-speed wind tunnel, and by measuring the induced vibratory bending stresses on the blades, the influence of gusts on flapwise bending moments was studied. Tests were made for two conditions of blade root fixation (fixed and teetering) and for a range of tip-speed ratios. Results indicate that maximum vibratory bending moments are of less importance for teetering rotor than for fixed rotor and give variation of gust effect with various parameters. (*AMR*, 1956, #546)

46. TRANSONIC FLUTTER INVESTIGATION OF A FIGHTER-AIRPLANE WING MODEL AND COMPARISON WITH A SYSTEMATIC PLAN-FORM SERIES
Land, N. S., Abbott, F. T., Jr.
October 7, 1955 (Declassified October 28, 1960)
National Advisory Committee for Aeronautics, Langley Aeronatuical Laboratory, Langley Field, Va.
RM L55B16

An investigation was made of the transonic flutter characteristics at zero lift of a model of a new fighter airplane wing. The results showed that the flutter characteristics of the fighter wing model were similar to those of a comparable systematic plan-form series of models partially reported in NACA RM L53G10a. It was also found that a change in airfoil section from one with a slight leading-edge droop and chord-extension to a symmetrical NACA section did not affect the flutter characteristics.

47. MODELS FOR AERO-ELASTIC INVESTIGATIONS
Templeton, H.
November 1955
Royal Aircraft Establishment, Farnborough, Great Britain
TN Struct. 179
(Also available as Current Papers 255, 1956, Aeronautical Research Council, London, Great Britain)

Scale relationships are derived for the design of prediction models (based on flutter equations having nondimensional square matrices of inertia), aerodynamic damping, aerodynamic stiffness, and structural stiffness coefficients, including flexible skin, segmental airfoil, stressed skin, solid, and semirigid types.

Different types of model construction are described and their main applications are defined. (*IAA*, June 1956)

48. AEROELASTICITY
Bisplingoff, R. L., Ashley, H., Halfman, R. L.
Addison-Wesley Publishing Company, Inc., Reading, Mass., 1955

49. WIND-TUNNEL FLUTTER TESTS ON A MODEL DELTA WING UNDER FIXED AND FREE ROOT CONDITIONS
Gaukroger, D. R., Chapple, E. W., Milln, A.
1955
Aeronautical Research Council, London, Great Britain
Reports and Memoranda 2826

Results are presented of low-speed tests on a half-span model delta wing with fixed-root conditions and with body freedoms in pitch and vertical translation. Critical flutter speed and frequency are given for variations in wing inertia axis, wing and fuselage center of gravity, fuselage pitching moment of inertia, and fuselage mass. Tests show that under root-free conditions, body freedom flutter occurs at low values of fuselage pitching moment of inertia, but at higher values the flutter is similar to that obtained with root-fixed conditions. (*IAA*, July 1956)

50. ROLLING POWER MEASUREMENTS AND COMPARATIVE CALCULATIONS FOR A FLEXIBLE MODEL WING CONSTRUCTED FROM XYLONITE
Lambourne, N. C., Batson, A. S., Chinneck, A.
(Appendix by H. C. Garner)
1955
Aeronautical Research Council, London, Great Britain
Reports and Memoranda 2895

Roll characteristics are given of an aeroelastic wing from calculation and wind-tunnel tests of a Xylonite (cellulose nitrate) model. Thickness of Xylonite required for contour smoothness was found to make the wing too stiff for low-speed testing. Comparison of test and calculated results shows fair agreement. (*AMR*, 1957, #834)

51. A PRELIMINARY INVESTIGATION OF THE EFFECTS OF FREQUENCY AND AMPLITUDE ON THE ROLLING DERIVATIVES OF AN UNSWEPT-WING MODEL OSCILLATING IN ROLL
Fisher, L. R., Lichtenstein, J. H., Williams, K. D.
January 1956
National Advisory Committee for Aeronautics, Washington, D.C.
TN-3554

Unsteady motion analysis is presented using a model with separable wing and tail assembly oscillating in roll through a range of frequencies and amplitudes at a 0-deg angle of attack and at one frequency and amplitude for two higher angles of attack, and with the model tested as a fuselage alone, a fuselage-tail combination, a fuselage-wing configuration, and as a complete configuration. Results indicate that (1) the fuselage-tail combination is the only configuration exhibiting yawing moment due to rolling of any appreciable magnitude, with the wing-interference effect on the tail contribution estimatable accurately by means of existing steady-state theory; (2) the frequency of amplitude has no noticeable effect on the magnitude of the damping in roll for the model or any of its components at a 0-deg angle of attack; and (3) the rolling derivative measured by the oscillation tests generally is consistent at low angles of attack with the derivatives determined by conventional rolling-flow steady-state tests, but at a high angle of attack the oscillatory yawing moment due to rolling for the fuselage-wing configuration differs from that obtained under steady-state conditions. (*IAA*, March 1956)

52. TEORIA E APPLICAZIONE DEI MODELLI STRUTTURALI NELLE COSTRUZIONI AERONÀUTICHE (THEORY AND APPLICATION OF STRUCTURAL MODELS FOR AERONAUTICAL DESIGN)
Gabrielli, G.
***Zeitschrift für Flugwissenschaften*, v. 4, no. 5/6, pp. 195–202, May/June 1956 (in Italian)**

It is premised that the use of structural models and the transfer of results of elasticity or failure tests from the models to the actual aircraft have not yet found sufficient application and appreciation in aeronautics, and hope is expressed for wider use of them.

The significance of the principal coefficients or factors adopted to determine loads on aeronautical structures is pointed out and the law of structural similarity is enunciated in its most general form. Reference is made to publications dated back to 1928, and support is given to the great usefulness of Herbert Wagner's diagram which permits an evaluation of the behavior of structures, with regard to local yields having different natures and origins, and an evaluation of the form of the section and of the more suitable materials to be employed in the most diverse cases. In this diagram the so-called index of structural load appears on the abscissa. Various authors, such as N. A. Bruyne and E. D. Keen, have extended the use of this index to several particular cases. The index of structural load is, in fact, a constant for every given structure and expresses the law of structural similarity applied to the limit of proportionality, to failure, or to whatever other degree of load. (*AMR*, 1956, #3551)

53. THE DESIGN AND TESTING OF SUPERSONIC FLUTTER MODELS
McCarthy, J. F., Jr., Halfman, R. L.
***Journal of the Aeronautical Sciences*, v. 23, no. 6, pp. 530–535, 577, June 1956**

The basic problems of flutter testing in the low supersonic speed range (Mach number 1.2–2.1) are outlined. The requirements for models which simulate full-scale airplanes when Mach number is included as a parameter are reviewed and compared with those where velocity is scaled so that flutter occurs in the range of a low-speed wind tunnel.

A particular type of construction for supersonic flutter models is described in detail. Methods of vibration testing, static testing, and flutter testing are discussed. Particular emphasis is placed on the technique of varying flow parameters rather than model parameters to precipitate flutter. The tool for varying flow parameters is the variable Mach number supersonic test section of the Massachusetts Institute of Technology Blowdown Wind Tunnel. The aerodynamic features of the supersonic test section are presented. (*AMR*, 1957, #251)

54. DESIGN OF STRUCTURAL MODELS, WITH APPLICATION TO STIFFENED PANELS UNDER COMBINED SHEAR AND COMPRESSION
Sandorff, P. E.
***Journal of the Aeronautical Sciences*, v. 23, no. 7, pp. 623–632, July 1956**

Structural tests on models are not necessarily to be performed on models which are geometrically similar to the original. For stability tests, e.g., if the problem in its generality is left out, and only some specific modes of failure are taken into consideration, test similarity will require that only some dimensionless parameters be maintained when passing from original to test conditions. A simplified time-and-money-saving technique will result.

An example is made on the column problem; it is also shown that some of the dimensionless parameters can be mutually influenced, and, therefore, a reduced number of them, resulting from their combinations, is to be considered.

Application is then presented to integrally stiffened skin panels under compression and shear. Dimensional analysis leads to establishing dimensionless parameters involved in instability phenomena. It can be proved theoretically that, for all practicable design variations, the isotropic plate of infinite aspect ratio can be considered as a model for stiffened skin panels. Experiments are described which have confirmed to a good degree the adequacy of the model.

Other applications are presented referring to cutout and diffusion problems, general instability of stiffened shells, thermal stresses (for which total energy supply often represents as much of a problem of intensity), and rupture phenomena. (*AMR*, 1957, #1396)

55. THE INVESTIGATION OF FLUID FLOW PROBLEMS BY MODEL TECHNIQUES
Gray, F. A., Robertson, A. D.
***Journal of the Institute of Fuel*, v. 29, no. 189, pp. 428–436, October 1956**

A laboratory established by United Steel Companies (England) for research in industrial fluid-flow problems is described. The nature of most tests requires the flow of air at low static pressure through a scale model rather than around it, as in most previous fluid-flow investigations. Problems presented are quite general, but are concerned primarily with flow in furnaces, flues, combustion chambers, etc. Methods of designing models, setting up equipment, making tests, and interpreting results are given. Geometric similarity and constancy of Reynolds number are taken as conditions for dynamic similarity, with no allowance for compressibility effects except for certain corrections when wide temperature variations occur. Treatment and results of several actual problems are illustrated. (*AMR*, 1957, #1434)

56. SIMILARITY CONDITIONS FOR TESTING HIGH SPEED AIRCRAFT MODELS
Ting, L.
November 1956
Polytechnic Institute of Brooklyn, N.Y.
PIBAL 308, OSR-TN-56-548, AF18(600)693
AD-110,367

Conditions are established to simultaneously simulate the flow field, the temperature distribution, and the deformation of an airplane or one of its components in free flight at high speed. The analysis is carried out in a case wherein the same gas (air) in the free flight condition is used for the test in the wind tunnel but the stagnation temperature may be different; i.e., the temperature scale is not necessarily equal to unity. This, in turn, makes it possible for the model material to differ from that of the prototype. For specific problems, approximations can be introduced which are justified by facts or mathematical arguments. Consequently, the number of similarity conditions can be reduced and the small scale model for the test in the wind tunnel can be designed. This concept is applied to a planar wing of low aspect ratio.

57. EXPERIMENTAL SCALE MODEL INVESTIGATION OF SHELL ROOFS
Benito, C.
***Publications of the International Association for Bridge Structural Engineering*, v. 16, pp. 35–38, 1956 (in French)**
(*AMR*, 1957, #2060)

58. EXPERIMENTAL ANALYSIS OF AIRCRAFT STRUCTURES BY MEANS OF PLASTIC MODELS
Zender, G. W.
***Society for Experimental Stress Analysis, Proceedings of the*, v. 14, no. 1, pp. 123–130, 1956**
(*AMR*, 1957, #408)

59. SIMILITUDE RELATIONS FOR FREE MODEL WIND-TUNNEL STUDIES OF STORE-DROPPING PROBLEMS
Sandahl, C. A., Faget, M. A.
January 1957
National Advisory Committee for Aeronautics, Washington, D.C.
TN-3907

Two methods are presented for dynamically scaling store models for wind-tunnel store-dropping studies. For each method the model and prototype Mach numbers are assumed to be necessarily equal and the Reynolds number effects are assumed to be negligible. The light-model method gives exact simulation of the store motions except that the vertical displacements are deficient. This deficiency is reduced as the vertical ejection velocity is increased, or it can be eliminated by accelerating the parent model upward at the instant of store separation. The heavy-model method, in which the parent model is stationary, gives complete simulation of the store motion except that the short-period longitudinal oscillaion is too poorly damped; this defect is of no serious consequence during the first phase of a drop because the time during which the store is critically close to the parent model is generally small compared with the period of the longitudinal oscillation. The heavy-model method is generally recommended for store-dropping studies. However, it is often impossible to make the models sufficiently heavy and with the proper moment of inertia. If such is the case, the light-model method is required.

A brief description of the method of conducting store-dropping tests in the preflight jet of the Langley Pilotless Aircraft Research Station at Wallops Island, Virginia, is given. (*AMR*, 1958, #266)

60. DITCHING INVESTIGATIONS OF DYNAMIC MODELS AND EFFECTS OF DESIGN PARAMETERS ON DITCHING CHARACTERISTICS
Fisher, L. J., Hoffman, E. L.
February 1957
National Advisory Committee for Aeronautics, Washington, D.C.
TN-3946

Data from ditching investigations conducted at the Langley Aeronautical Laboratory with dynamic scale models of various airplanes are presented in tabular form. The effects of design parameters on the ditching characteristics of airplanes, based on scale-model investigations and on full-scale ditchings, are discussed. Various ditching aids are also discussed as a means of improving ditching behavior. (*AMR*, 1958, #260)

61. SOME CONCEPTS AND PROBLEM AREAS IN AIRCRAFT FLUTTER
(From the 1957 Minta Martin Aeronautical Lecture)
Garrick, I. E.
March 1957
Institute of the Aeronautical Sciences, New York, N.Y.
Sherman M. Fairchild Fund Paper FF-15

General facets of the flutter fired, some historical background, and current trends are described. By specific examples or applications for simplified models, several problem areas of the subsonic, transonic, and supersonic speed ranges are illustrated. Some theoretical developments relating to linear and nonlinear lifting surface theory for nonsteady flows are indicated briefly. The role of the aeroelastic (flutter) model and some of the incidental techniques are noted.

62. A METHOD FOR EXAMINATION OF STORE SEPARATION FROM AIRCRAFT THROUGH DYNAMIC MODEL TESTING AT FULL-SCALE MACH NUMBER
Deitchman, S. J.
***Journal of the Aeronautical Sciences,* v. 24, no. 4, pp. 275–280, April 1957**

The need for study of the motion of stores after launch or jettison from high-speed aircraft has led the designer to resort to dynamic model testing at full-scale Mach numbers as a direct analytical technique. Accordingly, it has been found useful to formulate a set of similarity laws for testing the cases most commonly encountered – i.e., free falling bodies and fin- or spin-stabilized powered projectiles. Consideration is also given to obtaining model to full-scale similarity of the jet of a powered projectile for study of its effect on the launching aircraft. Requirements for simulation of the effects of fuel in a full or partially full tank are examined qualitatively. Some simulation errors that may be encountered are examined and evaluated. (*AMR*, 1958, #2282)

63. EXPERIMENTALLY DETERMINED NATURAL VIBRATION MODES OF SOME CANTILEVER-WING FLUTTER MODELS BY USING AN ACCELERATION METHOD
Hanson, P. W., Tuovila, W. J.
April 1957
National Advisory Committee for Aeronautics, Washington, D.C.
TN-4010

Three-dimensional views are presented of the first three natural vibration mode shapes of ten cantilever-wing models. A table of normalized deflections at six spanwise and five chordwise stations is included for each mode. These mode shapes were measured by an unusual experimental technique using grains of sand as accelerometers. The technique, which is particularly suited for measuring mode shapes of small wing models, is described and some of the difficulties likely to be encountered in applying the technique are discussed. (*AMR*, 1957, #2435)

64. FLUTTER MODEL TESTING AT TRANSONIC SPEEDS
(Presented at the IAS 25th Annual Meeting, New York, N.Y., January 28–31, 1957)
Targoff, W. P., White, R. P., Jr.
***Aeronautical Engineering Review,* v. 16, no. 6, pp. 58–62, June 1957**
(Also available as Preprint 706, Institute of the Aeronautical Sciences, New York, N.Y.)

Flutter research on reflection plane models of straight, swept, and delta wings in a 3 × 4-ft transonic test facility is described. (*AMR*, 1957, #4121)

65. ANALYTICAL STUDY OF SIMILARITY PARAMETERS FOR AERODYNAMIC MODEL TESTING AT HIGH TEMPERATURES. PART II: DESIGN CRITERIA FOR WING-TYPE AEROTHERMOELASTIC MODELS
Scipio, L. A., II
August 1957
Minnesota, University of, Aeronautical Engineering Department, Rosemount Aeronautical Laboratories, Minneapolis

WADC-TR-57-496, Part II, AF 18(600)-851
AD-150,974

Design criteria are presented for simulating aerodynamic heating and aeroelastic effects on high-speed aircrafts by wind-tunnel models. Relationships are discussed for interpreting data obtained from model measurements in terms of the total prototype deformation.

66. THEORY OF AIRCRAFT STRUCTURAL MODELS SUBJECT TO AERODYNAMIC HEATING AND EXTERNAL LOADS
O'Sullivan, W. J., Jr.
September 1957
National Advisory Committee for Aeronautics, Washington, D.C.
TN-4115

Similarity rules are formulated for model and prototype of an aircraft deformed and stressed by its aerodynamic heating and aerodynamic loads. Orthodox methods (π-theorem) of dimensional analysis are employed. It is concluded that similarity of model is possible except as to angular motion. (*AMR*, 1958, #796)

67. ANALYTICAL STUDY OF SIMILARITY PARAMETERS FOR AERODYNAMIC MODEL TESTING AT HIGH TEMPERATURES. PART I: SIMILARITY CRITERIA FOR SOLID- AND SHELL-TYPE AERO-THERMOELASTIC MODELS
Scipio, L. A., II, Teng, L. C.
November 1957
Minnesota, University of, Aeronautical Engineering Department, Rosemount Aeronautical Laboratories, Minneapolis
WADC-TR-57-496, Part I, AF 18(600)-851
AD-142,264

Similarity parameters for wind tunnel testing of thermal stresses and strains produced in free flight due to aerodynamic heating are studied.

68. THE BENDING STRESSES IN CANTILEVER PLATES BY MOIRÉ FRINGES
Palmer, P. J.
***Aircraft Engineering*, v. 29, no. 346, pp. 377–380, December 1957**

The bending stresses in plate models can be determined by means of the experimentally produced Moiré fringes, which give directly the gradients at all points of the surface of the model. It is shown that this technique can be used for cantilever plates with either uniform or nonuniform thickness provided that, in the latter case, the thickness is not large. The experimental technique is simple and yields stresses to an accuracy of about 10 percent and deflections to an accuracy of about 5 percent. Care must be exercised, however, at the edges of the model. The technique and apparatus are described and details of the experimental technique are given and discussed. Some resulting experimental fringe patterns are shown and analyzed. (*AMR*, 1958, #3932)

69. AN EXPERIMENTAL AND THEORETICAL STUDY OF THE EFFECT OF FUEL ON PITCHING-TRANSLATION FLUTTER APPENDIX—FLUTTER AND DIVERGENCE EQUATIONS FOR TWO-DIMENSIONAL WING-TANK CONFIGURATION
Sewall, J. L.
December 1957
National Advisory Committee for Aeronautics, Washington, D.C.
TN-4166

Analytical flutter studies for two-dimensional fuel-loaded wing models are presented, and a comparison of experimental results is made for bending-to-torsion frequency ratios near one. One of the models is made so that water, simulating fuel, can be carried internally in three compartments separated by sealed spanwise partitions. Flutter speeds of this model for all fuel loads are highest for the compartmental-emptying sequence from front to rear. In the other model, fluid is carried externally in a pylon-mounted fuel tank without baffles. Theory and experiment are in good agreement for both models. (*IAA*, February 1958)

70. STRUCTURAL VIBRATIONS PRODUCED BY GROUND MOTION
Hudson, D. E., Housner, G. W.
***American Society of Civil Engineers, Transactions of the*, v. 122, pp. 705–721, 1957**

Dynamic loads (caused by a large quarry blast) on a steel-frame mill building were measured and used as a basis for improving the strength-weight efficiency of such structures. The dynamic response has been computed by means of simplified models. Ingenious use of dynamics theory supplements the somewhat limited test facilities and correlates measured ground motion with the building floor acceleration response. (*AMR*, 1960, #1723)

71. THE APPLICATION OF ROCKET SLED TECHNIQUES TO FLUTTER TESTING
(Presented at the IAS 25th Annual Meeting, January 28–31, 1957, and at the 3rd Annual Supersonic Track Symposium, China Lake, Calif.)
Laidlaw, R. W., Beals, V. L., Jr.
1957
Institute of the Aeronautical Sciences, New York, N.Y.
Preprint 666

The role of the rocket-propelled sled in the flutter design process is discussed. The details of sled design, instrumentation, data reduction, and test procedures, as they apply to rocket sled flutter tests, are presented. A graphical ballistic method for predicting rocket sizes, firing sequences, and the derived sled performance is discussed.

72. **MEASUREMENTS OF UNSTEADY AERODYNAMIC COEFFICIENTS AND FLUTTER TESTS IN MODELS**
Dat, R.
***La Recherche Aéronautique*, no. 62, pp. 45–56, January–February 1958 (in French)**

Some general considerations are itemized for test preparation and performance at both subsonic and supersonic flow. The results are derived generally from a careful study of the flutter equations. Topics included are (1) measurement of the elastic constants, masses, and aerodynamic forces, (2) wind-tunnel tests, (3) flutter tests, and (4) model design. (*AMR*, 1960, #4287)

73. **MODELING TECHNIQUE AND THEORY FOR AEROELASTIC SIMILARITY IN BLOW-DOWN WIND-TUNNEL TESTS**
Broglio, L.
March 1958
Air Force Office of Scientific Research, Washington, D.C.
TN-58-902
AD-204,283
(Also available as SIAR 30, Universita di Roma, Scuola Ingegneria Aeronautica, Italy)

The problem of aeroelastic similarity for wing and wing-tail models used in wind-tunnel tests is considered. A procedure is described for designing aeroelastically similar wind-tunnel models. Linearized supersonic flow theory, neglecting thickness effects, is applied to the calculation of deflections of an elastic, uncambered wing with supersonic leading and trailing edges. Structural influence coefficients for the wing are assumed known.

Mach 3 wind-tunnel data are presented for three swept-wing models (made of steel, an aluminum alloy, and a magnesium alloy) tested with and without a tail. Model elastic deflections were measured optically, and aerodynamic loads measured by means of strain gage balances.

Calculated model deflections and aerodynamic loadings, based on the theory presented, compare fairly well with experimental data. (*AMR*, 1959, #4737)

74. **APPLICATION OF SIMILITUDE THEORY TO THE PROBLEM OF FUEL SLOSHING IN RIGID TANKS**
Abramson, H. N., Martin, R. J., Ransleben, G. E., Jr.
May 23, 1958
Southwest Research Institute, Engineering Mechanics Department, San Antonio, Texas
TR-1, DA-23-072-ORD-1251

Similitude theory is applied to the problem of fuel sloshing in accelerated tanks to establish criteria for the design of model experiments. The ranges of significant parameters and the selection of model liquids are discussed.

75. **MODEL TESTS IN THREE-DIMENSIONS AT STEVENS**
(Presented at Second Seminar on Ship Behavior at Sea)
Numata, E.
June 1958
Stevens Institute of Technology, Hoboken, N.J.
Paper

76. **RESULTS OF AN EXPERIMENTAL INVESTIGATION OF SMALL VISCOUS DAMPERS**
Silveira, M. A., Maglieri, D. J., Brooks, G. W.
June 1958
National Advisory Committee for Aeronautics, Washington, D.C.
TN-4257

Damping and spring forces for several kinds of dampers used in dynamic model tests are given, including types in which a piston displaces oil and types in which a rod slides through a silicone fluid. Results show the effect on forces of maximum piston velocity, kind of fluid, and temperature. Effects of frequency and amplitude are usually small. (*AMR*, 1958, #4863)

77. **USE OF THE KERNEL FUNCTION IN A THREE-DIMENSIONAL FLUTTER ANALYSIS WITH APPLICATION TO A FLUTTER-TESTED DELTA-WING MODEL**
APPENDIX A—STRUCTURAL PROPERTIES OF DELTA-WING MODEL
APPENDIX B—EVALUATION OF ELEMENTS OF DETERMINANTAL FLUTTER EQUATION AND APPLICATION TO A SPECIFIC CONFIGURATION
Woolston, D. S., Sewall, J. L.
September 1958
National Advisory Committee for Aeronautics, Washington, D.C.
TN-4395

A flutter analysis of the modal, or Rayleigh-Ritz, type was applied to a delta semispan wing with a leading-edge sweep angle of 45 deg which fluttered as a cantilever at a Mach number of 0.85. The converged solutions obtained for the flutter speed are about 5 percent less than the experimental value when the first three or four natural-vibration modes are used to approximate the flutter mode. (*IAA*, January 1959)

78. **ESSAIS DE FLOTTEMENT SUR MAQUETTES AUTOPROPULSÉES SOL-SOL, DANS LE DOMAINE TRANSSONIQUE; COMPARAISON DES RÉSULTATS OBTENUS EN AIR LIBRE ET DES RÉSULTATS CALCULÉS OU OBTENUS EN SOUFFLERIE (FLUTTER TESTS ON SELF-PROPELLED GROUND-TO-GROUND MODELS IN THE TRANSONIC REGION: COMPARISON OF RESULTS OBTAINED IN FREE FLIGHT AND RESULTS COMPUTED OR OBTAINED IN WIND TUNNELS)**
Loiseau, H.
***La Recherche Aéronautique*, no. 66, pp. 43–51, September–October 1958 (in French)**

Flutter tests on self-propelled ground-to-ground models in the transonic region are described. Model types are discussed, and a comparison is made between wind-tunnel and free-flight measurements on dynamically similar wings as well as between theoretical and experimental results. (*IAA*, February 1959)

79. **THE DETERMINATION OF THE FLUTTER SPEED OF A T-TAIL UNIT BY CALCULATIONS, MODEL TESTS AND FLIGHT FLUTTER TESTS**
(Presented at 14th Meeting of NATO, AGARD, Wind Tunnel and Model Testing Panel, Copenhagen, Denmark, October 20–21, 1958)
Baldock, J. C. A.
October 1958
North Atlantic Treaty Organization, Paris, France
AGARD Report 221

An investigation was conducted to determine the fin flutter speed of the Handley Page Victor. The comparison of estimates for fin flutter speed and the results of the flight tests showed that good agreement was obtained for the fin flutter speed in spite of differences in the ground resonance modes and in the subcritical response. General observations are made regarding the value of low speed wind-tunnel flutter models and the safety aspect of flight flutter tests. (*IAA*, 1961, #61-807)

80. **AEROELASTIC MODELS FOR LOW-SPEED TEST**
Fiorini, V.
***Aerotecnica*, v. 38, no. 5, pp. 260–268, October 1958**
(in Italian)

Flutter investigations for high-aspect-ratio wing and tail plane to a flight speed of 0.8–0.85 Mach number are very convenient with aeroelastic models in a low-speed wind tunnel.

Results of dimensional analysis of the flutter equations are reported, and similarity laws for aerodynamic, elastic, and inertial forces are applied to the design and construction of the subject models. A monospar model, in which only the spar has strength attributions and the balsa sections have aerodynamic and inertial functions, is described in detail.

Tests preliminary to the flutter investigation in a wind tunnel—such as determination of torsional and flexural rigidity for the spar, positioning of *c g*, and determination of the moment of polar inertia at the *c g* axis parallel to the elastic axis of the balsa sections—are summarized. (*AMR*, 1959, #5266)

81. **APPLICATION D'UNE MÉTHODE DE DÉTERMINATION EXPÉRIMENTALE DES FORCES AÉRODYNAMIQUES INSTATIONNAIRES RELATIVES A UNE AILE RIGIDE OSCILLANT EN SOUFFLERIE (APPLICATION OF A METHOD OF EXPERIMENTAL DETERMINATION OF NONSTATIONARY AERODYNAMIC FORCES TO A RIGID WING OSCILLATING IN A SUBSONIC WIND TUNNEL)**
Dat, R., Trubert, M.
1958
Office National d'Études et de Recherches Aéronautique, Chatillon-sous-Bagneux, France
NT 44 (in French)

A method is developed and applied to the experimental determination of nonstationary air forces of a rigid wing oscillating between the walls of a subsonic wind tunnel. A rectangular wing section representing the model, and flutter tests with two degrees of freedom were used to verify the accuracy of the results. Description of the installation, comparison with theory, and application to a three-dimensional case are included. (*IAA*, September 1958)

82. **DYNAMIC MODEL TESTS OF AN UNCONVENTIONAL LANDING CONFIGURATION**
Deutschmann, J. N., Schlessinger, M. (Bell Aircraft Corporation)
In "Proceedings of the National Specialists Meetings on Dynamics and Aeroelasticity, Fort Worth, Texas, November 6–7, 1958" p. 128
Institute of the Aeronautical Sciences, New York, N.Y., 1958

83. **WIND-TUNNEL TESTS ON THE EFFECT OF BODY FREEDOMS ON THE FLUTTER OF A MODEL WING CARRYING A LOCALIZED MASS**
Gaukroger, D. R., Chapple, E. W.
1958
Aeronautical Research Council, London, Great Britain
Reports and Memoranda 3081

Test results are presented for the flutter of a sweptback wing carrying a localized mass and having symmetric and antisymmetric freedoms of the root. The tests were made on a model wing of 23-deg sweepback, the chordwise and the spanwise positions of a localized mass being varied for two localized values. The inertia conditions of the fuselage were constant and representative of full scale in most of the symmetric flutter tests. The fuselage rolling moment of inertia was varied for the antisymmetric tests. Results indicate that, in general, the symmetric flutter case is more critical than the antisymmetric for masses at outboard positions on the wing, but for heavy inboard masses the antisymmetric case may be more critical. Graphical representations of symmetric and antisymmetric flutter are given. The results appear too complex for prediction of the effects of mass loading on the flutter of particular aircraft. (*IAA*, October 1958)

84. **TRANSONIC EFFECTS ON T-TAIL FLUTTER APPENDIX—SUMMARY OF STIFFNESS AND MASS PROPERTIES OF THE MODELS**
Stahle, C. V.
February 1959
Martin Company, Baltimore, Md.
RM 24

The transonic effects of stabilizer dihedral and hull stiffness on the flutter characteristics of T-tails are investigated. Experimental data on the antisymmetric flutter characteristics and the subcritical behavior of T-tails in the transonic range are presented, and a spectrum analysis technique is described for determining the subcritical behavior from the model response to tunnel turbulence. The response spectra were obtained from analysis of magnetic tape records and were combined with turbulence data to provide damping trends. Ten dynamically similar models having stabilizer dihedral angles of 0, 15, and 30 deg were tested from Mach number 0.5–1.15. The flutter mode of all models tested was predominated by fin bending and hull lateral bending motion, and the flutter condition was characterized by the convergence of the frequencies of the first and second modes. A gull stabilizer unit with 15-deg positive dihedral at the root section and 15-deg negative dihedral at the tip section was tested. The results indicate that the flutter point of the gull configuration is 15 percent higher than that of the 15-deg dihedral models, but it is lower than the flutter boundary of the models without dihedral. (*IAA*, June 1959)

85. SIMULATION OF FUEL SLOSHING CHARACTERISTICS IN MISSILE TANKS BY USE OF SMALL MODELS
Abramson, H. N., Ransleben, G. E., Jr.
March 20, 1959
Southwest Research Institute, Engineering Mechanics Department, San Antonio, Texas
TR-3, DA-23-072-ORD-1251

Similitude theory is applied to the problem of fuel sloshing in accelerated tanks to establish criteria for the design of model experiments. The ranges of significant parameters and the selection of model liquids are discussed. The results of experiments made on small models are compared with those obtained on full-scale tanks, for two different types of damping devices.

86. THE USE OF MODELS IN AEROELASTIC ANALYSIS
(Presented at CAI–IAS Joint Meetings, Ottawa, Canada, October 7–8, 1958)
McKillop, J. A.
***Canadian Aeronautical Journal*, v. 5, no. 3. pp. 89–98, March 1959**
(Also available as Preprint 850, Canadian Aeronautical Institute–Institute of the Aeronautical Sciences, New York, N.Y.)

The role played by elastic models as supplements to analysis in the design process of a modern aircraft is reviewed. The theory of aeroelastic model design is briefly treated, and the types of models required for different applications are discussed. Model construction, instrumentation, and test techniques are given, and some conclusions are derived regarding the part played by aeroelastic models in the design process. (*IAA*, December 1958)

87. EFFECTS OF WING STIFFNESS CHANGES ON THE MODES AND FREQUENCIES OF A MODEL DELTA AIRCRAFT
Webb, D. R. B.
April 1959
Royal Aircraft Establishment, Farnborough, Great Britain
R. Struct. 245

Resonance tests are presented which show the effects of stiffness changes in the leading and trailing edge spars on the frequencies and modes of vibration. The results indicate that, while considerable frequency changes were apparent, the general shape of the modes of vibration did not change significantly. The criterion of modal orthogonality proved to be useful in checking the purity of the modes. A minimum of two vibrators, whose force output could be independently varied, is found necessary to obtain good phase relationship between pickup stations. (*IAA*, March 1959)

88. MODEL STUDY OF FLOATING DRYDOCK MOORING FORCES
Wiegel, R. L., Clough, R. W., Dilley, R. A., Williams, J. E.
***International Shipbuilding Progress*, v. 6, no. 56, pp. 147–159, April 1959**

The problem of wave-induced forces on ships' moorings is discussed together with the details of a laboratory study of an AFDL-1 (floating drydock). The resulting mooring line forces and the correlations between prototype and model natural periods of surge and sway are given. (*AMR*, 1960, #3763)

89. FLUTTER TESTS IN FREE AIR ON LAUNCHED MODELS
Loiseau, H.
May–June 1959
Office National d'Études et de Recherches Aéronautique, Chatillon-sous-Bagneux, France
Publication 70, pp. 47–55 (in French)

Flight-test results which supplement earlier studies on flutter are briefly noted. A series of free-flight models of wings with ailerons are air-launched from an airplane and flutter speeds observed. Good agreement is noted between these results and those obtained by calculation and in wind tunnels. (*AMR*, 1960, #4292)

90. MODELS AS DESIGN AID
Witt, D. R.
***Electrical Manufacturing*, v. 63, no. 6. pp. 109–111, June 1959**

Various forms of design models and their selection for successive phases of presenting design ideas are discussed. A guide to materials and fabricating methods used in model making is given. (*EI*, 1959)

91. SCALE-MODEL TESTS INCREASE ODDS OF FULL-SCALE SUCCESS
Ledgerwood, B. K.
***Control Engineering*, v. 6, pp. 147–154, September 1959**

Models can be used in three ways: (1) as research tools, (2) as steps in the design process, and (3) as safe and inexpensive methods of studying possible improvements in an operating process. In almost every case, the major problems are designing a scale model that is truly representative of the large-scale system and accurately measuring the variables of interest while the model is being tested. Achieving a truly representative model requires a knowledge of similarity principles and model theory. Measuring the model variables often brings special instrumentation and control techniques into play. The basic problems are briefly discussed with emphasis on instrumentation covering model techniques in the fields of ships, flight vehicles, furnaces, rolling mills and flow processes.

92. STRUCTURAL MODELS PREVIEW STRESS AND STRAIN
Simon, R., Carlson, R. G., Bert, C. W.
***Product Engineering*, v. 30, pp. 55–62, October 26, 1959**

This article is divided into three parts. Part I, "Theory of Similitude," by Dr. Ralph Simon, lays down the relationships and conditions that must be met for a model to behave like the actual structure. It gives the conditions for similarity, proportional stress and strain, affect of weight on performance, and violation of geometric similarity.

Part II, "Building the Better Model," by Raymond G. Carlson, discusses the use of photoelastic materials, plaster of paris, type metal, rubber and plastics for various kinds of models.

Part III, "The Structural Model at Work," by Charles W. Bert, describes the need to use high precision instruments in measurements to be made on models.

93. ADVANTAGES AND LIMITATIONS OF MODELS
Sobey, A. J.
***Royal Aeronautical Society, Journal of the*, v. 63, no. 587, pp. 646–656; discussion, pp. 656–658, November 1959**

The use of models for structural test investigations in the presence of kinetic heating effects is examined. Principal features of this complex process are discussed with respect to external air flow, internal heat transfer, and elastic response. Of these, the second is found to have the greatest influence on design. A typical structure is analyzed. (*EI*, 1960)

94. DYNAMIC MEASUREMENTS ON PROPELLER MODELS
Van Manen, J. D., Wereldsma, R.
***International Shipbuilding Progress*, v. 6, no. 63, pp. 473–481, November 1959**

A dynamometer for measuring the thrust and torque of ship-propeller models under dynamic conditions is described and analyzed. Design properties of the system (such as natural frequency, damping coefficients, etc.) are discussed, and the electronic test instrumentation is considered in detail. Sample vibration and propeller performance records obtained on four- and five-bladed propellers are presented and analyzed. A sampling technique provides good reproducibility of the periodic data. (*AMR*, 1960, #5533)

95. SIMILARITY AND DIMENSIONAL METHODS IN MECHANICS
Sedov, L. I.
Friedman, M., Translator (from 4th Russian Edition)
(Translation edited by M. Holt)
Academic Press, Inc., New York, N.Y. and London, England, printed in Great Britain, 1959

96. APLIKACE MODELŮ PRO VYŠETŘOVÁNÍ AEROELASTICKÝCH STAVŮ (THE USE OF MODELS IN THE INVESTIGATION OF AEROELASTIC CONDITIONS)
Tajovský, M.
***Zpravodaj VZLÚ*, no. 6, pp. 17–25, 1959 (in Czechoslovakian)**

The use of models in the examination of aeroelastic conditions is discussed. Experience gained in designing and testing dynamically similar models constructed to determine the critical vibration frequencies of aircraft parts is cited. Basic principles of vibration and methods for the solution of vibration problems are presented. Similarity conditions for aeroelastic models, construction, and vibration and wind-tunnel tests are described. (*IAA*, 1961, #61-797)

97. PRINCIPLES OF DESIGN OF DYNAMICALLY SIMILAR MODELS FOR LARGE PROPELLANT TANKS
Sandorff, P. E.
January 1960
National Aeronautics and Space Administration, Washington, D.C.
TN D-99

Physical variables entering the problem of liquid propellant motion (sloshing) and its dynamic effects on the container are listed. The nondimensional groups obtained by conventional dimensional analysis are examined and the possibility of construction of dynamically similar models is discussed. It is shown that it is impossible to achieve Reynolds similarity in a reduced scale model. The use of various materials for models of the structure and the propellant is discussed. However, with no experience of an actual model construction yet available, the conclusions are only indicative of the possibilities. (*AMR*, 1960, #4312)

98. DYNAMIC MODEL INVESTIGATION OF A LANDING-GEAR CONFIGURATION CONSISTING OF A SINGLE MAIN SKID AND A NOSE WHEEL
Faber, S.
February 1960
National Aeronautics and Space Administration, Washington, D.C.
TN D-213
AD-231,525

Variations in nose-wheel shimmy damping and in nose-wheel skid geometry were investigated to determine their effect on directional stability during the landing ground run. The tests were made by towing the model on a moving-belt runway at a constant belt speed. Nose-wheel steering and forms of shimmy damping other than viscous damping about the strut axis were found to produce stable configurations.

99. SLOSHING OF LIQUIDS IN CIRCULAR CANALS AND SPHERICAL TANKS
Budiansky, B.
***Journal of the Aerospace Sciences*, v. 27, no. 3, pp. 161–173, March 1960**

Theoretical calculations are made of the natural modes and frequencies of small-amplitude sloshing of liquids in partially filled circular canals and spherical tanks. An integral-equation approach is used to analyze the circular canal for arbitrary depth of liquid. A similar approach for the spherical tank provides modes and frequencies for the nearly full and half-full cases. These results, together with the known behavior of the nearly empty tank, are used in conjunction with the trends established for the circular canal as a basis for estimating frequencies for arbitrary depth of liquid in the spherical tank. The dynamic analysis of the container-fluid system by means of the mode-superposition approach is discussed, and modal parameters required in such analyses are presented.

100. FLUTTER INVESTIGATION OF A TRUE-SPEED DYNAMIC MODEL WITH VARIOUS TIP-TANK CONFIGURATIONS
Sewall, J. L., Herr, R. W., Igoe, W. B.
March 1960
National Aeronautics and Space Administration, Washington, D.C.
TN D-178 (Supersedes NACA RM L54I19, AD-58,538)
AD-233,661

A ⅙-scale wing tip-tank model, representative of an unswept-wing fighter airplane, was flutter tested in the Langley 16-ft transonic tunnel. The wing was of spar-balsa segment-type construction and was dynamically scaled to flutter at the same speed as a typical full-scale configuration. Each tip tank housed a device for arresting flutter by providing for a quick shift in the tip-tank center of gravity. This device proved to be very effective in stopping symmetric flutter when the tip-tank center of gravity was shifted forward of the wing elastic axis. Experimental flutter results indicating the effects of external stores are compared with the results of a conventional Rayleigh-Ritz type of flutter analysis which predicted flutter speeds that were excessively conservative with respect to experiment as the tip-tank center of gravity approached the elastic axis.

101. FLUTTER TESTING THE 880 IN A TRANSONIC WIND TUNNEL
MacLellan, A.
***Aero/Space Engineering*, v. 19, pp. 37–43, April 1960**

Considerations in the use of a wind-tunnel model are presented and the selection of an appropriate model discussed. Instrumentation and other related features are described and the actual wind-tunnel test and results obtained reported.

102. INVESTIGATION OF THE NATURAL FREQUENCIES OF FLUIDS IN SPHERICAL AND CYLINDRICAL TANKS
McCarty, J. L., Stephens, D. G.
May 1960
National Aeronautics and Space Administration, Langley Research Center, Langley Field, Va.
TN D-252

Several propellant-tank configurations applicable to missile designs were oscillated to study the natural frequencies of a contained fluid over a range of tank sizes and fluid depths and to develop expressions relating these natural fluid frequencies to certain physical parameters. The configurations included spheres and circular cylinders that could be oriented with respect to the direction of oscillation.

103. MODEL-MAKING MADE EASY WITH NUMERICAL CONTROL
Kaye, P.
***Control Engineering*, v. 7, p. 40, July 1960**
(*AS&T*, 1960)

104. A NEW APPROACH TO SAFE FLIGHT FLUTTER TESTING
Zisfein, M. G., D'Ewart, B. B.
September 1960
Bell Aerospace Corporation, Bell Aerosystems Company Division, Buffalo, N.Y.
Report 9015-19-002, AFOSR TN 60-1027

A basic research program is discussed which is concerned with the synthesis, analysis, and experimental evaluation of a new method of flight flutter testing. The method is based on the well-known fact that small changes in mass distribution can drastically change the vibrational properties of an oscillating aerodynamic surface and can bring about substantial changes in its flutter speed. It employs a jet device to simulate the force effects of mass and, thereby, to create an apparent change in the mass distribution of an aerodynamic surface. This apparent mass change can be easily manipulated to make flutter come or go, and, therefore, can be used as a safe, fail safe, positive, flight-flutter test device. The historical background, a discussion of the basic principles of "jet mass" and its effect on flutter, and a description of the design details of two jet-mass prototypes and a wind-tunnel flutter model are presented. The laboratory and wind-tunnel tests on the prototype jet-mass systems are studied, and a statement of conclusions and recommendations for future jet-mass-system development is included. (*IAA*, 1961, #61-152)

105. CONTRÔLES SUR MAQUETTES LARGUÉES DÉFORMABLES À FRÉQUENCES RÉDUITES ÉLEVÉES (CONTROLS FOR MODELS IN FREE FLIGHT WHICH CAN BE DEFORMED AT REDUCED HIGH FREQUENCIES)
Loiseau, H.
***La Recherche Aéronautique*, pp. 47–55, January–February 1961 (in French)**

An experimental investigation of flutter frequencies and damping, and of the critical speed for flutter is conducted. Of the three different models used, two are "simple" and one is "multiple" (i.e., having wings plus engine pylons, called a "crossed" wing). Measurements are made in the wind tunnel by means of strain gages and accelerometers. The apparatus

113. INVESTIGATION OF VIBRATION CHARACTERISTICS OF 1/5-SCALE MODEL OF SATURN SA-1
Mixson, J. S., Catherine, J. J. (Langley Research Center, Langley Field, Va.)
In "30th Symposium on Shock, Vibration, and Associated Environments, Detroit, Mich., October 10–12, 1961," pp. 30–39
U.S. Department of Defense, Washington, D.C.
Bulletin 30, Part IV

The 1/5-scale model and the test apparatus for investigation of the *Saturn* vehicle vibration are described. Test results of natural frequencies, mode shapes, and damping coefficients of bending vibration are illustrated. (*AI/A*, 1962, #60,580)

114. AN EXPERIMENTAL INVESTIGATION OF THE EFFECTS OF MACH NUMBER, STABILIZER DIHEDRAL, AND FIN TORSIONAL STIFFNESS ON THE TRANSONIC FLUTTER CHARACTERISTICS OF A TEE-TAIL
Land, N. S., Fox, A. G.
October 1961
National Aeronautics and Space Administration, Washington, D.C.
TN D-924

Wind-tunnel investigation of the transonic flutter characteristics of elastically and dynamically scaled tee-tail models is presented. It is found that removal of the 15-deg dihedral of the stabilizer raises the flutter boundary to higher dynamic pressures. The effect of Mach number on the flutter boundary is different for dihedral angles of 0 and 15 deg. It is also found that the dynamic pressure at the flutter boundary increases approximately linearly with the torsional stiffness of the skin. High-speed motion pictures show that the flutter mode consists primarily of fin bending and fin torsion. (*IAA* 1961, #61-9035)

115. STUDY IN THE USE OF STRUCTURAL MODELS FOR SONIC FATIGUE
Gray, C. L.
November 1961
Northrop Corporation, Norair Division, Hawthorne, Calif.
NOR-61-215, ASD TR-61-547, AF 33(616)-7030
(Also available from Office of Technical Services, Washington, D.C.)

The feasibility of employing reduced-scale structural models for sonic fatigue testing is examined theoretically and experimentally. Scaling laws for structure and for jet noise sources are presented and theoretical fatigue aspects discussed. Application of the theory to simple flight-vehicle type structure is then investigated. Twenty-five panel specimens in three scales and eighteen fatigue coupons in two scales are tested to failure with proportionately scaled forcing functions. The results indicate that an empirical relationship between scale factor and fatigue life exists, and that fatigue modeling techniques are feasible and practical.

116. SCALE-MODEL PRINCIPLES
Hudson, D. E.
In "Shock and Vibration Handbook; Volume II. Data Analysis, Testing and Methods of Control" pp. 27-1–27-18
Harris C. M., Crede C. E., Editors
McGraw-Hill Book Company, Inc., New York, N.Y., 1961

Vibration problems often can be conveniently studied by the construction and testing of a scale model. A description of types of models which may be considered for mechanical prototypes is given. The advantages and disadvantages of using models, and conditions for designing and testing them are discussed. Dimensional analysis and the theory of models are treated in detail. Model construction and testing are reviewed and the application of models is outlined.

117. INVESTIGATION OF RATIONAL SCALING PROCEDURE FOR LIQUID FUEL ROCKET ENGINES
Bixson, L. L., Deboi, H. H.
June 1962
Sundstrand Corporation, Sundstrand Aviation, Engineering and Testing Laboratories, Denver, Colo.
SSD TDR-62-78, AF 18(603)-107

The rocket-scaling research program was undertaken to conduct both an analytical and an experimental investigation of rational approaches to the solution of the general problem of high frequency combustion instability in liquid propellant rocket engines. A review of existing similarity analyses, which had been applied successfully to the scaling of steady aerothermochemistry and low frequency combustion instability in flow and combustion systems, was performed under this program. The analyses were then extended to derive specific, as well as generalized, rules of rational scaling procedures for high frequency combustion instability.

118. SIMILARITY LAWS FOR AEROTHERMOELASTIC TESTING
Dugundji, J., Calligeros, J.
Journal of the Aerospace Sciences, v. 29, no. 8, pp. 935–950, August 1962

The similarity laws for aerothermoelastic testing are presented for the range $M_\infty < 3.5$, $T < 1{,}000°F$. These are obtained by making nondimensional the appropriate governing equations of the individual external aerodynamic flow, heat conduction to the interior, and stress-deflection problems which make up the combined aerothermoelastic problem.

For the general aerothermoelastic model, where the model is placed in a high-stagnation-temperature wind tunnel, similitude is shown to be very difficult to achieve for a scale ratio other than unity. The primary conflict occurs between the free-stream Mach number M_∞, Reynolds number Re_∞, aeroelastic parameter $\rho_\infty V^2/E_0$, heat conduction parameter k_∞/K_0, and thermal expansion parameter $\alpha_0 T_0$.

is described, and results are presented in tabular and graphical form. (*IAA*, 1961, #61-5056)

106. SCALE MODELS FOR THERMO-AEROELASTIC RESEARCH
Molyneux, W. G.
March 1961
Royal Aircraft Establishment, Farnborough, Great Britain
TN Struct. 294

An investigation of the parameters to be satisfied for thermo-aeroelastic similarity is presented. The results seem to indicate the necessity for a 1:1 correspondence in model and aircraft if complete similarity of thermo-aeroelastic effects is desired. An approach to similarity can be achieved by the assumption of several enumerated limiting considerations, but experimental and analytical work is required to check the validity of those assumptions. A layout for a hot wind tunnel is also proposed that would answer the needs of thermo-aeroelastic work, at present inadequately available. (*IAA*, 1961, #61-8077)

107. MÉTHODE D'ADJUSTEMENT D'UNE MAQUETTE "FONCTIONNELLEMENT SEMBLABLE" À PARTIR D'UNE PREMIÈRE RÉALISATION (A METHOD OF ADJUSTING A "FUNCTIONALLY SIMILAR" MODEL FROM AN ORIGINAL CONCEPT)
Kappus, R., Clerc, D.
***La Recherche Aéronautique*, pp. 45–54, March–April 1961 (in French)**

Two criteria for models used in studies of flutter are derived. The first is for the elastic similarity of the model to the prototype, the second for the similarity of mass. The latter criterion permits direct adjustment of the model by the addition or removal of small corrective masses. The analysis is fully described, and the method is applied to a clamped rectangular wing as an example. (*IAA*, 1961, #61-5055)

108. SCALE-MODEL FLIGHT DYNAMICS TESTING ON HIGH-SPEED TRACKS
Woods, C. E. (Naval Ordnance Test Station, China Lake, Calif.)
In "Symposium Proceedings: Structural Dynamics of High Speed Flight," Cosponsored by Aerospace Industries and Office of Naval Research, Los Angeles, Calif., April 24–26, 1961, ACR-62, Volume I, p. 268
Aerospace Industries Association of America, Inc., Los Angeles, Calif.
(Also available from Office of Technical Services, Washington, D.C.)

109. WALL PRESSURE DISTRIBUTIONS DURING SLOSHING IN RIGID TANKS
Abramson, H. N., Ransleben, G. E., Jr.
***ARS Journal*, v. 31, pp. 545–547, April 1961**

Some measurements (made under Army sponsorship) are reported for wall pressure distributions obtained during sloshing experiments with rigid model cylindrical tanks having flat bottoms and undergoing transverse oscillation. Total force and moment, obtained by integration of the measured pressures and the pressure distributions themselves, are compared with theoretical predictions. (*IAA*, 1961, #61-4067)

110. THE USE OF ACOUSTIC SCALE MODELS FOR INVESTIGATION NEAR FIELD NOISE OF JET AND ROCKET ENGINES
Morgan, W. V., Sutherland, L. C., Young, K. J.
April 1961
Boeing Airplane Company, Aero-Space Division, Flight Dynamics Laboratory, Seattle, Wash.
WADD-TR-61-178, AF 33(616)-6834

Analytical and experimental studies have been made to examine the feasibility of using acoustic scale models for near-field noise investigations. Analyses show that the important characteristics of noise generation, propagation, and measurement can be scaled. A relatively few deviations from this involve small errors which are generally negligible in the near field. The most straightforward model is seen to be one which duplicates the gas flow parameters of the full scale engine. The validity of such models has been demonstrated by a series of tests for a wide variety of nozzle exit conditions.

111. WING FLUTTER TESTS BY A SEGMENTED AEROFOIL MODEL
Imachi, I., Sugiyama, Y.
***Japan Society for Aeronautical and Space Science, Tokyo, Journal of*, v. 9, pp. 5–9, July 1961 (in Japanese, with English summary)**

An experimental and theoretical investigation of the flutter speeds and flutter frequencies of a segmented cantilever wing is presented. Values calculated from a flutter analysis based on two uncoupled modes of vibration are found to be somewhat lower than the experimental data, particularly for the flutter frequencies. (*IAA*, 1961, #61-8064)

112. STRESS AND DEFORMATION ANALYSIS FROM REDUCED-SCALE PLASTIC MODEL TESTING
Johnson, A. E., Jr., Homewood, R. H.
***Experimental Mechanics*, v. 1, no. 9, pp. 81–90, September 1961**

Use of plastic scale models for analysis of missile nose cone structures is discussed. Special strain gage application is made and testing techniques required are given. Two cases cited for use of inexpensive simplified models are: (1) stress and deformation study of thin, constant thickness, shallow spherical shell supported by circumferential line reaction and subjected to uniform external pressure; and (2) determination of stress and deformation in variable-thickness, shallow spherical shell with several cutouts. (*EI*, 1961)

Means of dealing with this basic conflict are presented. These include (1) looking at more specialized situations, such as the behavior of wing structures and of thin solid plate lifting surfaces, and panel flutter, where the aerothermoelastic similarity parameters assume less restrictive forms; (2) the use of "incomplete aerothermoelastic" testing in which the pressure and/or heating rates are estimated in advance and applied artificially to the model; and (3) the use of "restricted purpose" models investigating separately one or another facet of the complete aerothermoelastic problem.

Some numerical examples of modeling for the general aerothermoelastic case as well as for the specialized situations mentioned in (1) are given. Finally, extension of the aerothermoelastic similarity laws to higher speeds and temperatures is discussed.

119. **ON SCALING LAWS FOR MATERIAL DAMPING**
Crandall, S. H. (Massachusetts Institute of Technology, Cambridge)
December 1962
National Aeronautics and Space Administration, Washington, D.C.
TN D-1467
(Also available from Office of Technical Services, Washington, D.C.)

Similarity analyses are made to provide scaling laws which indicate the effects of amplitude, frequency, and material properties on the resonant damping experienced by structural elements when the damping is due to internal material properties. Two nonlinear damping "laws" are considered. Correlations provided by the scaling laws were performed on data from a large number of tests with steel, brass, and aluminum cantilever beams. (*STAR*, 1963, #N63-10,987)

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